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ORIGINAL ARTICLE
ORİJİNAL ARAŞTIRMA

The Prehospital Care of Diabetic Ketoacidosis in a Referral Hospital Pediatric Intensive Care Unit and the Utility of Telemedicine

Bir Sevk Hastanesindeki Çocuk Yoğun Bakım Ünitesinde Diyabetik Ketoasidozun Hastane Öncesi Bakımı ve Teletıpın Faydası

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Abstract

Aim: This study aimed to investigate the effects of the type of admission (ambulance/outpatient clinic) and telemedicine use in patients admitted to the pediatric intensive care unit (PICU) with diabetic ketoacidosis (DKA).

Material and Method: A retrospective observational study was conducted at a referral PICU between January 2019 and December 2021. Telemedicine was utilized for patients admitted from other hospitals and through the emergency response system. The study recorded the type of admission (ambulance/outpatient clinic), the efficacy of telemedicine, clinical manifestations, and outcomes. The severity of the disease, complications, and length of stay in the PICU were compared between two groups: ambulance/outpatient and those with telemedicine applied/none applied.

Results: A total of 144 patients were included in the study. Of these, 51.4% were male, and the median age was 13.0 years (range: 2-18 years). About 45.1% of patients were transferred to the PICU by ambulance. Telemedicine was utilized in 56 (38.8%) patients. The usage of ambulance and telemedicine was higher in newly diagnosed and younger patients ($p < 0.001$ and $p = 0.0014$, respectively). No significant differences between the groups using and not using ambulance and telemedicine regarding the Glasgow Coma Scale, Pediatric Mortality Risk Score III, and mean HbA1c level were found. Although complications such as hypophosphatemia and acute kidney injury were more prevalent in the group that did not receive telemedicine, no statistically significant difference was observed and there was no mortality.

Conclusion: There is not enough data in the literature on the prehospital care of DKA patients admitted to PICU. Although there was no significant difference between prehospital care and outcomes in this study, we think that the low complication rate is related to telemedicine.

Keywords: Prehospital care, telemedicine, diabetic ketoacidosis, pediatric intensive care unit

Öz

Giriş: Bu çalışmada diyabetik ketoasidoz (DKA) nedeniyle çocuk yoğun bakım ünitesine (ÇYBÜ) başvuran hastalarda başvuru şeklinin (ambulans/poliklinik) ve teletıp kullanımının etkilerinin araştırılması amaçlandı.

Gereç ve Yöntem: Ocak 2019 ile Aralık 2021 tarihleri arasında retrospektif gözlemsel bir çalışma yapıldı. Başka hastanelerden kabul edilen hastalar için teletıp kullanıldı. Çalışmada, hastaların başvuru türü (ambulans/ayakta tedavi kliniği), teletıp etkinliği, klinik belirtiler ve sonuçlar kaydedildi. Hastalığın şiddeti, komplikasyonları ve ÇYBÜ'de kalış süresi iki grup arasında karşılaştırıldı: ambulans/ayakta tedavi görenler ve teletıp uygulanan/hiç uygulanmayanlar.

Bulgular: Çalışmaya 144 hasta dahil edildi. Bunların %51,4'ü erkekti ve ortanca yaş 13,0 (aralık: 2-18 yıl) yıldı. Hastaların yaklaşık %45,1'i ambulansla başvurdu. Teletıp 56 hastada (%38,8) kullanıldı. Ambulans ve teletıp kullanımı yeni tanı alan ve küçük yaş hastalarda daha yüksekti (sırasıyla $p < 0,001$ ve $p = 0,0014$). Ambulans ve teletıp kullanan ve kullanmayan gruplar arasında Glasgow Koma Skalası, Pediatrik Mortalite Risk Skoru III ve ortalama HbA1c düzeyi açısından anlamlı fark bulunamadı. Teletıp almayan grupta hipofosfatemi ve akut böbrek hasarı gibi komplikasyonlar daha sık görülmesine rağmen istatistiksel olarak anlamlı bir fark gözlenmedi. Çlışmada mortalite gözlenmedi.

Sonuç: ÇYBÜ'ye başvuran DKA'lı hastaların hastane öncesi bakımına ilişkin literatürde yeterli veri bulunmamaktadır. Bu çalışmada hastane öncesi bakım ve sonuçlar arasında anlamlı bir fark olmamasına rağmen komplikasyon oranının düşük olmasının teletıp ile ilgili olabileceğini düşünüyoruz.

Anahtar Kelimeler: Hastane öncesi bakım, teletıp, diyabetik ketoasidoz, çocuk yoğun bakım ünitesi

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INTRODUCTION

Diabetic ketoacidosis (DKA) is the most common cause of hospitalization, morbidity, and mortality in type 1 diabetes mellitus (T1DM) in children (1). The most common cause of DKA at this age is new-onset T1DM. DKA also commonly occurs in previously diagnosed patients who use insufficient insulin or skip insulin therapy, suffer from infections, or have other comorbidities (2). DKA occurs in approximately 30-40% of children at the time of diagnosis of T1DM and a rate of 6-8% per year in children with established diabetes (2-4).

DKA is a serious complication of diabetes characterized by high blood sugar levels (hyperglycemia), ketone accumulation, and acidosis. Early diagnosis of diabetic ketoacidosis (DKA) in individuals with diabetes is of paramount importance due to the potential for severe complications and even life-threatening outcomes associated with this condition. The most common complications of DKA are cerebral damage, cognitive impairment, venous thrombosis, elevated pancreatic enzymes, acute kidney injury, cardiac arrhythmias due to electrolyte disturbances, and pulmonary disease (2-7). The mortality rate of DKA in children is 0.15-0.30% (4-6). The 2022 International Society for Pediatric and Adolescent Diabetes consensus guidelines recommend urgent screening and treatment to prevent DKA complications. In this situation, the accessibility of health centers plays an important role in determining the patient's condition at the onset of diabetes (4).

Telemedicine is defined as "the use of medical information exchanged from one location to another via electronic communication to improve a patient's clinical health status" (8). Telemedicine enables medical care to be delivered remotely through the electronic transmission of health data (9). While telemedicine has made significant advances in various areas of healthcare, its role in managing DKA is not entirely clear due to the acute and critical nature of this condition. Because DKA is a medical emergency that requires immediate and comprehensive personal medical care and monitoring. It can support pre-hospital care by guiding paramedics and emergency medical personnel on initial management steps for individuals suspected of having DKA. Teleconsultations can also aid in deciding the appropriate level of care and facilitating timely referrals to specialized facilities. Telemedicine can also be used as a tool that complements traditional in-person care, especially in critical situations like DKA. Utilizing telemedicine appropriately, especially in remote or underserved areas, can improve diabetes management, enhance patient outcomes, and contribute to preventing complications like DKA. To our knowledge, few studies in the literature examine the use of prehospital care and telemedicine in patients with DKA in the pediatric intensive care unit (PICU). In this study, we aimed to examine the impact of admission type and the benefits of telemedicine on treatment, complications, length of hospital stay, and prognosis.

MATERIAL AND METHOD

The study was carried out with the permission of Mersin University Clinical Researches Ethics Committee (Date: 15.12.2021, Decision No: 2021/755). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

Patients admitted to the 30-bed PICU of a referral hospital with a diagnosis of DKA between January 2019 and December 2021 were retrospectively evaluated. Patient data were obtained from the hospital database. The study included newly diagnosed patients with diabetic ketoacidosis (DKA) aged between 1 month and 18 years, as well as patients with Type 1 diabetes mellitus (DM) who experienced DKA during their follow-up. Exclusion criteria comprised patients over 18 years of age, those with missing data in their medical records, and individuals admitted to intensive care through in-hospital referrals (service patients). Patient demographics, such as age, sex, anthropometric measures, age of T1DM diagnosis, type of emergency department admission (ED), and PICU (admission time, ambulance/by parent or caregiver), use of telemedicine during transport, clinical presentations, causes of DKA, laboratory parameters, biochemical changes, the severity of DKA, Glasgow Coma Scale (GCS), pediatric risk of mortality score III (PRISM III), triggers of DKA, and management, complications, prognosis, and length of stay in the PICU and hospital were recorded.

DKA is defined as a pH < 7.30 and/or a bicarbonate level < 15 mmol/L. By the criteria outlined in the most recent guidelines, the acceptable bicarbonate (HCO_3) level has been revised to 18 mmol/l. However, for our study, which predates 2022, the HCO_3 value used was 15 mmol/l. New-onset and previously diagnosed patients were included in the study. The age of the patients at the time of diagnosis and the number of DKA attacks in the last 3 years were determined. DKA was classified as mild, moderate, or severe according to severity. Mild DKA is classified by a pH of 7.20–7.30 and a serum bicarbonate level between 10-18 mEq/L; moderate DKA by a pH between 7.10–7.20 and a serum bicarbonate level of 9 to less than 5 mEq/L; and severe DKA by a pH of less than 7.10 and a bicarbonate level of less than 5 mEq/L [4]. All severe and moderate DKA patients and symptomatic [altered mental status (AMS), and Glasgow Coma Scale (GCS) < 14] mild DKA patients with a pH of < 7.25 were admitted to the pediatric intensive care unit. Pediatric risk of mortality score III (PRISM III) was used to determine disease severity and predict outcomes (10).

Mild DKA patients were admitted to the PICU because of an insufficient number of out-of-hours nurses and doctors in the inpatient service or the absence of a pediatric endocrinologist during the time they were admitted to the hospital. There was a COVID-19 pandemic at the time the study was conducted. For

this reason, some mild DKA patients were admitted to the PICU because they had symptoms consistent with COVID-19. All children with diabetes mellitus were referred to our hospital as per the policy of the provincial health directorate. All patients were referred by the emergency call center. Before admission, telemedicine consultations (via telephone or video conference, as needed) were conducted with referring physicians through the emergency department call center. For newly diagnosed patients, their diagnoses were made by the physicians at the initial center. The majority of newly diagnosed patients fell into the moderate and severe ketoacidosis category. Unfortunately, the initial diagnosis for these patients took place in locations where specialist doctors were unavailable. Consequently, the first medical professionals these patients encountered were general practitioners. These patients were referred to us due to metabolic acidosis, and through the referral system, telemedicine assistance was provided to the referring physicians. Initial treatment plans were devised in collaboration with these physicians. The treatment for both previously diagnosed and newly diagnosed patients was coordinated by the pediatric endocrinology and pediatric intensive care specialist at the referring hospital.

All patients were admitted to the PICU using a transfer form. These forms provided a detailed account of all treatments administered during prehospital care. All primary care physicians provided a summary of the patient's medical history and interventions on the transfer form, including detailed information on the treatments administered during the patient's stay. Furthermore, the medical teams transporting the patient recorded the procedures performed during the journey on the transfer and handover form. The initial team at the referral center assessed the implementation of recommended treatments via telemedicine. Telemedicine continued within the ambulance throughout transport. Transport time was approximately 40 minutes at the shortest distance and 3 hours at the longest distance in patients considered to be referred. The treatment was conducted following the DKA treatment protocol specific to our country's pediatric intensive care, as outlined in the reference (11).

Newly diagnosed patients received fluid deficit treatment at the initial center they visited. Blood gas and blood sugar levels were continuously monitored. In cases where the distance between the initial center and the PICU exceeded three hours and the patients presented with severe ketoacidosis, blood gas monitoring was conducted. In rare cases, insulin infusion was initiated in a controlled manner before the patient's departure. For patients arriving via long-distance ambulance, paramedics in the ambulance provided telemedicine assistance to ensure the safe transportation of the patient.

The insulin treatments administered at home to patients previously diagnosed with T1DM were evaluated and discussed by both their primary care doctors at the initial center and the PICU team. All of these procedures were accomplished through the utilization of telemedicine, facilitated by emergency medical dispatchers. Previously diagnosed T1DM patients who sought assistance from home did not have a prior record of self-administering extra doses of insulin. During their diabetes management education at endocrinology outpatient clinics, they were explicitly instructed not to administer additional insulin doses in cases of moderate and severe DKA. Instead, they were advised to promptly seek medical attention at the hospital.

Patients were evaluated according to the way they applied to the emergency department and PICU (ambulance/parents-caregivers and telemedicine applied/not applied). The severity of the disease, blood gas parameters, electrolyte disorders that are experienced during the treatment, complications, and length of stay in the PICU and the hospital were compared between the groups.

Statistical Analyzes

Statistics Package for the Social Sciences, version 23.0 software (IBM Inc., Chicago, IL, USA) was used for statistical analysis. Continuous data are represented by the mean and standard deviation or median and interquartile range (IQR), as appropriate. Categorical variables are expressed by frequency and cross tables. The descriptive statistics of the variables, mean (min-max), median (min-max), frequency distribution, and percentage indicators were examined. Mean values were used in parametric tests and median values were used in non-parametric tests. The chi-square test (or Fisher's exact probability test) was used to compare demographics. Mann-Whitney U or t-test was performed for two independent groups, as appropriate. Values of $p<0.005$ were regarded as statistically significant.

RESULTS

Overall, 144 patients were enrolled and more than half of the patients (51.4%) were male. We excluded 21 patients due to missing data and four patients who were hospitalized in other services before being admitted to the PICU. While the median age of the patients was 13.0 [intequartile range (IQR) 10-15] years, the median diagnosis age of T1DM was 11.0 (IQR 6-13) years (**Table 1**). In the study, 66 (45.8%) patients were newly diagnosed with T1DM; 10 (15%) patients were under five years of age, and 24 (36.3%) patients were under 10 years old at the time of diagnosis. Of all patients, 47 (32.6%) were under the age of 10. The majority of the patients (63.2%) were admitted to the PICU in the out of working hours.

Table 1. Demographics, admission features, symptoms, etiology, and severity of Diabetic Ketoacidosis on the admission to Emergency department.

Age (year) [median (min-max, IQR)]	13.0 (2-18, 10-15)
T1DM Diagnosis Age (year) [median (min-max, IQR)]	11.0 (1-17, 9-13)
Gender (F/M)	70/74
Admission time (n, %)	
On working hours	53 (36.8)
Out-of-working hours	91 (63.2)
Admission type (n, %)	
Ambulance	65 (45.1)
Parents / Caregivers	79 (54.9)
Symptoms (n, %)	
Tachypnea	93 (64.5)
Vomiting	43 (29.9)
Weakness	37 (25.7)
Headache	14 (9.7)
AMS	8 (5.6)
Etiology (n, %)	
Skipping insulin therapy	67 (46.5)
Newly diagnosed T1DM	66 (45.8)
Infection	11 (7.6)
Severity (n, %)	
Mild	71 (49.3)
Moderate	52 (36.1)
Severe	21 (14.6)
Telemedicine (n%)	
Applied	56 (38.8%)
No applied	88 (61.1%)

AMS: altered mental status, DKA: Diabetic ketoacidosis, ED: emergency department, F: female, GCS: Glasgow Coma Scale, IQR: interquartile range, M: male, min: minimum, max: maximum, T1DM: type 1 diabetes mellitus

The most common symptoms were tachypnea (64.5%), altered mental status (AMS) (%31.9), headache (29.9%), and weakness (25.7%) (**Table 1**). The most common causes of DKA attacks were "skipping insulin therapy" (46.5%), newly diagnosed T1DM (45.8%), and infection (7.6%). Almost three-quarters of the patients had no chronic disease. While nearly half of the patients (49.3%) had moderate DKA; 36.1% had severe DKA and 14.6% had mild DKA. Among the patients previously diagnosed with T1DM, those who had their last control more than 3 months ago were more common (69.2%).

In the study, 65 patients (54.9%) were admitted to the ED by parents or caregivers; only 45.1% of patients used an ambulance (**Table 1**). Ambulance usage rates of patients diagnosed with T1DM after the first DKA attack were significantly higher than those of patients with T1DM with previous diagnoses ($p<0.001$). Ambulance usage rates of severe and mild DKA patients were similar, and there was no relationship between the DKA severities (46.2% vs. 42.9%, respectively) ($p = 0.804$). In addition, the younger DKA patients had a significantly high ambulance usage rate ($p = 0.014$). When assessing patients admitted to the PICU based on their GCS scores, there was no notable difference between the two groups (ambulance/parents or caregivers) ($p = 0.351$). However, it's important to note that the rate of ambulance utilization was noticeably greater during the initial admission to the PICU for DKA cases ($p = 0.008$), as outlined in **Table 2**.

Table 2: The comparison of transport type and T1DM diagnosis time, DKA severity, age, GCS, and PICU admission numbers

	Transport type		p
	Ambulance	Parents / Caregivers	
T1DM Diagnosis [n (%)]			
New	43 (65.2)	23 (34.8)	<0.001
Old	22 (28.2)	56 (71.8)	
DKA severity [n (%)]			
Mild	9 (42.9)	12 (57.1)	
Moderate	32 (45.1)	39 (54.9)	0.804
Severe	24 (46.2)	28 (53.8)	
Age [median (min-max, IQR)]	12 (2-17, 10-14)	14 (2-18, 11-16)	0.014
GCS [median (min-max, IQR)]	13 (10-15, 12-13)	13 (11-15, 12-13)	0.351
PICU admission number [n (%)]			
1	39 (54.2)	33 (45.8)	0.008
≥2	26 (36.1)	46 (63.9)	

DKA: Diabetic Ketoacidosis, ED: emergency department, GCS: Glasgow Coma scale, IQR: interquartile range, min: minimum, max: maximum, PICU: Pediatric Intensive Care Unit, T1DM: type 1 diabetes mellitus

Of the patients who came by ambulance, 56 (86%) were admitted by referral from other hospitals. These patients had received only isotonic IV fluids during the transport; only three patients came with the combination of IV fluid and a tightly controlled insulin infusion. The reason for giving insulin infusions to those severe DKA patients was that their hospital arrival time was longer than two hours, and they had received an upper limit of IV fluid in the primary care hospitals.

The blood gas parameters and HbA1c levels of the patients on admission are shown in **Table 3**. The median number of PICU hospitalizations for patients after the first T1DM diagnosis was 2 (min 1 - max 7, IQR 1-3). Ambulance usage rates of patients who had ≤1 PICU admission history were significantly higher than those who had ≥2 PICU admission histories ($p = 0.008$) (**Table 2**). Transport type and the utilization of telemedicine did not significantly impact the PRISM III score during the period of PICU admission ($p = 0.975$ and $p = 0.353$, respectively). The median PRISM III score of the patients in the PICU was 8 (min 4 - max 14, IQR 6-10). While complications developed in 25% (n = 36) of the patients during the intensive care follow-up, hypophosphatemia, hypoglycemia, and acute kidney injury (AKI) were the most common (**Table 4**). Cerebral edema was not seen in the PICU. Although complications such as hypophosphatemia and acute kidney injury were higher in the group that did not receive telemedicine, the study findings indicated that the implementation of telemedicine had no statistically significant effect on the incidence of complications in patients with diabetic ketoacidosis (DKA) ($p= 0.351$).

Table 3. Comparative analysis of blood gas and biochemical parameters on admission to the Emergency Department: the impact of transport types and telemedicine utilization

Parameters	Transport type		Telemedicine	
	Ambulance (n=65)	Parents / Caregivers (n=79)	Applied Telemedicine (n=56)	No Telemedicine (n=88)
Blood gas [median (IQR)]				
pH	7.1 (7.0-7.1)	7.1 (7.1-7.2)	7.1 (7.0-7.2)	7.1 (7.1-7.2)
$PaCO_2$ (mmHg)	19 (16-21)	20 (16-24)	19 (16-21)	20 (16-24)
HCO_3 (mmol/L)	5.0 (4-9)	7.5 (5.3-10.0)	5.0 (4-9)	7.0 (5.5-10.0)
BE	-21.0 (-23-(-18))	-20.0 (-23-(-17))	-21.0 (-23-(-19))	-20.0 (-23-(-17))
Lactate (mmol/L)	2.04 (1.4-2.9)	2.1 (1.5-3.0)	2.1 (1.4-2.9)	2.1 (1.4-3.0)
Biochemical [median (IQR)]				
Na (mEq/L)	132 (130-134)	132 (130-135)	132 (130-135)	132 (130-135)
K (mEq/L)	4.6 (3.9-5.1)	4.6 (4.1-5.2)	4.6 (3.9-5.0)	4.6 (4.0-5.2)
P (U/L)	3.46 (2.6-4.6)	4.18 (3.4-5.1)	3.5 (2.6-4.6)	4.1 (3.1-5.1)
Glucose (mg/dL)	521 (400-614)	525 (401-604)	524 (598-598)	523 (402-606)
Urea (mg/dL)	32 (24-38)	34 (24-44)	30 (24-38)	36 (24-44)
Kreatinin (mg/dL)	0.9 (0.8-1.3)	0.9 (0.8-1.2)	0.9 (0.8-1.2)	1.0 (0.9-1.2)
HbA1c (%)	12.1 (10.3-14.2)	12.6 (10.6-13.9)	12.3 (10.4-14.2)	12.4 (10.3-13.9)

BE: Base excess, ED: Emergency department, HbA1c: Hemoglobin A1c, HCO_3: bicarbonate, IQR: Interquartile range, K: potassium, min: minimum, max: maximum, Na: sodium, P: phosphorus, $PaCO_2$: partial pressure of carbon dioxide.

Table 4: The complications, PRISM scores, and length of stay of diabetic ketoacidosis patients in the pediatric intensive care unit

	Transport type		Telemedicine		
	Ambulance	Parents / Caregivers	Applied Telemedicine	No Telemedicine	P value
Complications n,(%)					
Hypophosphatemia	15 (10.4)	15 (10.4)	12 (8.3)	18 (12.5)	0.351
Hypoglycemia	2 (1.3)	1 (0.6)	2 (1.3)	1 (0.6)	
AKI	0	2 (1.3)	0	2 (1.3)	
Hypokalemia	0	1 (0.6)	0	1 (0.6)	
None	48 (33.3)	60 (41.6)	42 (29.1)	66 (45.8)	
PRISM score [median (min-max, IQR)]	8 (4-14, 6-10)	8 (4-14, 6-10)	9 (4-14, 7-10)	8 (4-14, 6-10)	0.456
LOS (h) [median (min-max, IQR)]	16.0 (6-280, 11-26)	16.0 (6-38, 11-20)	18.0 (6-280, 11-26)	14.5 (6-38, 11-20)	0.238

AKI: Acute kidney injury, DKA: Diabetic ketoacidosis, h: hour, IQR: Interquartile range, LOS: Length of stay, min: minimum, max: maximum, PICU: Pediatric Intensive Care Unit, PRISM: Pediatric Risk of Mortality Score

Fifty-six patients (38.9%) were treated with telemedicine. Among the patients who received telemedicine, the entirety of them were transported via ambulance, whereas 86.2% of the patients who arrived by ambulance had previously undergone telemedicine. The utilization of telemedicine was significantly higher among newly diagnosed T1DM patients compared to those with a pre-existing diagnosis, with rates of 73.2% and 28.4%, respectively (p<0.001) (**Table 5**). In comparing patients who underwent telemedicine with those who did not, it was noted that the telemedicine group comprised a significantly younger cohort (median 11.0 vs. 14.0 years, p<0.001). However, there was no statistically significant difference between the two groups regarding GCS assessment (p = 0.056) (**Table 5**).

The median length of stay of the patients in the PICU and the hospital, was 16.0 hours (min 6.0 - maximum 11.7 days, IQR 11.0 - 22.8 hours) and 5.5 days (min 1.0 - maximum 14.0 days, IQR 4.0 – 8.0 days), respectively (**Table 4**). The study revealed that the mode of transport, whether by ambulance or accompanied by parents/caregivers, did not significantly impact the length of stay in the PICU (16.0 hours for both groups, p = 0.137). However, it was determined that patients who underwent telemedicine had significantly longer durations of hospitalization and PICU admission compared to those who did not receive telemedicine (median 26.0 vs. 19.5 days, 18.0 vs. 14.5 days, respectively; p<0.001 and p = 0.017) (**Table 4**).

Table 5. The comparison of telemedicine usage and Type 1 Diabetes Mellitus diagnosis time, age, Glasgow Coma Scale, and pediatric intensive care unit admission numbers

	Telemedicine		p
	Applied Telemedicine	No Telemedicine	
Transport type [n (%)]			
Ambulance	56 (86.2)	9 (13.8)	<0.001
Parents / Caregivers	0 (0)	79 (100)	
Age [median (min-max, IQR)]	11 (2-17, 8.3-14)	14 (2-18, 11-16)	<0.001
T1DM Diagnosis [n (%)]			
New	41 (62.1)	25 (37.9)	<0.001
Old	15 (19.2)	63 (80.8)	
GCS [median (min-max, IQR)]	13 (10-15, 12-13)	13 (11-15, 12-14)	0.056
Complications [n (%)]			
+	14 (25.0)	22 (25.0)	0.351
-	42 (75.0)	66 (75.0)	

DKA: Diabetic ketoacidosis, GCS: Glasgow Coma Scale, IQR: interquartile range, min: minimum, max: maximum, T1DM: type 1 diabetes mellitus

DISCUSSION

T1DM is one of the most common chronic diseases in childhood, its rates continue to rise, and 18% of new diagnoses occur in children aged 9 years and younger (12). Its increased incidence in young children has been associated with delays in diagnosis (13). Early diagnosis and early access to health services reduce morbidity and mortality (14,15).

DKA tends to be more prevalent in young children and adolescents, with the peak incidence observed in the 10 to 14 age group (12,13,15). In our study, we found that the median age of the patients experiencing DKA was 13 years. Diabetic ketoacidosis (DKA) is not linked to a specific gender; both males and females with type 1 diabetes can experience DKA (11, 12, 14,15). In our study, we observed no gender difference in DKA occurrences. DKA is a complication of diabetes that arises from a severe lack of insulin, leading to dangerously high levels of ketones and blood sugar (1-5, 7,10). The risk of DKA is primarily associated with factors such as overall diabetes management, insulin usage, illness, infections, missed insulin doses, and individual health circumstances, rather than gender. In our study, the most common reason was skipping insulin treatment.

Treatment of DKA is teamwork and requires trained healthcare professionals (2,4,7,16). In our study, we evaluated patients with a diagnosis of DKA in a single referral center in a highly populated city. There is a limited number of studies in the literature evaluating the use of prehospital care of patients, emergency medical services (EMS), and the impact of transport-based care for children with DKA (17, 18). In our study, we observed a higher rate of admission to the PICU via ambulance compared to the study conducted by Turan et al. Additionally, within our study, there was a higher incidence of ambulance utilization among patients newly diagnosed with T1DM (17).

In our study, although the number of young, newly diagnosed, and severe DKA patients was higher in the group referred by ambulance, there was no expected significant difference between the groups in terms of complications, laboratory values at the time of admission, or length of stay in the intensive care unit. We thought that the favorable outcomes observed in the PICU for these patients could be attributed to the implementation of telemedicine during transport. However, due to the lack of homogeneity in our groups and the incompatibility of the study group with regression analysis, we were unable to provide definitive insights into this matter. Due to the long transport times of the patients, we managed the treatment via telemedicine.

Telemedicine was originally conceived as a way to reach patients in remote areas with insufficient numbers of healthcare professionals. The use of telehealth and telemedicine received a lot of attention during COVID-19. Today, this technology's use continues to become more widespread (9, 19-22). Studies on the use of telemedicine in the glycemic control of T1DM also existed before COVID-19. Shulman et al. reported that there was no apparent effect of the telemedicine interventions on hemoglobin A1c (HbA1c), severe hypoglycemia, or diabetic ketoacidosis in 2010 (23). Although telemedicine appeared to be effective in glycemic control in another meta-analysis involving adult patients, the evidence was mostly reported from small studies of relatively short duration (24). Although the number of studies reporting the use of telemedicine in the follow-up of patients with T1DM is gradually increasing in the literature, there is no study regarding the use of telemedicine during the transfer of pediatric patients to the PICU due to DKA (21-25).

In our study, we attribute fewer complications to the telemedicine group. Telemedicine allows healthcare teams to collaborate and consult remotely, especially in cases where expertise may not be readily available on-site. It can bridge geographical barriers and provide individuals in remote or underserved areas with access to specialized diabetes care and expertise in managing DKA. This can lead to improved outcomes by ensuring that individuals receive appropriate and timely care. This collaborative approach can enhance the quality of care for individuals experiencing DKA.

In our study, we found higher rates of telemedicine use in patients with new onset T1DM, at younger ages, and in patients referred by ambulance. These results were similar to the transport method (without ambulance/ambulance). Effective use of the emergency referral chain and accessibility to pediatric intensivists and pediatric endocrinologists were important. Telemedicine was administered to patients arriving by ambulance. Although most of these patients were newly diagnosed, younger, and had moderate-to-severe DKA, there was no significant difference between the two groups who received and did not receive telemedicine in terms of GCS and complications at the time of admission to the hospital. There was a similarity between the patient's admission PRISM III scores and the length of stay in the PICU. We think that the reason for this is the treatment of patients using telemedicine. In our study, we cannot evaluate whether the results would have been different if telemedicine had not been used because no control group did not use telemedicine.

Telemedicine has indeed played a significant role in improving the management of DKA by enabling more immediate intervention and closer monitoring during transport. Telemedicine allows healthcare professionals to assess and provide immediate guidance for managing DKA during transport. ın our study, emergency medical personnel communicated

with us who are remote healthcare providers discuss the patient's condition, vital signs, laboratory results, and treatment plan. Telemedicine enabled continuous monitoring of the patient's condition while in transit. This allowed for real-time assessment and adjustment of the treatment plan, ensuring that the patient is stable and receiving appropriate care during transport. In our study, no complication was observed during transport. Telemedicine provided a platform for emergency medical personnel to consult with pediatric intensivists and endocrinologists remotely. This consultation aided in confirming the diagnosis, optimizing treatment plans, and ensuring that appropriate protocols were followed during transport. We think that telemedicine is very important because it provides easy access to a limited number of specialist doctors working in reference hospitals in developing countries.

In our study, we thought that telemedicine enhances the ability to intervene promptly and monitor DKA patients closely, improving outcomes by ensuring timely and appropriate management. Our work coincided with the COVID-19 pandemic, during which telemedicine was extensively utilized. However, it's important to note that telemedicine is a complement to, not a replacement for, in-person medical care, and severe cases of DKA may still require immediate, in-person medical attention.

In the literature, the use of telemedicine has increased in patients followed by DM, especially during the COVID-19 pandemic (26, 27). Periodic consultations using telemedicine enable the care of people with diabetes while limiting the need for in-person attendance at diabetes clinics. Current literature offers limited insights into the application of telemedicine for pediatric T1DM patients. However, a local study involving 8 children with diabetes in our country shed light on its potential (28). The study highlighted that telemedicine could significantly contribute to maintaining optimal glycemic control, particularly for those newly diagnosed with T1DM, especially during exceptional situations like pandemics.

Telemedicine represents a promising avenue for enhancing care for DKA. Healthcare providers and politicians have a critical role in establishing a comprehensive program focused on leveraging telemedicine for diagnosing, monitoring, and managing pediatric DKA. Moreover, the development of standardized guidelines for telemedicine's application in evaluating and managing pediatric DKA is essential. To optimize care, teleconsultation services should be enhanced, seamlessly integrating telemedicine platforms into existing healthcare systems. This integration will facilitate remote consultations and continuous monitoring of pediatric DKA patients. Teleconsultations play a pivotal role in ensuring prompt and accurate diagnosis of DKA cases. This is especially crucial in remote or underserved areas where access to specialized care is limited, as highlighted in our study. Providing accessible teleconsultations with endocrinologists and pediatric specialists can significantly improve the quality of care for these young patients.

Another issue that should be considered in our study is the high rate of DKA in previously diagnosed patients. In the last multicenter study conducted in our country, the incidence of DKA was reported to be 49% in previously diagnosed T1DM patients (29). Risk factors for recurrent DKA were identified in one study, particularly in females, adolescents, and those from inner regional or socioeconomically disadvantaged areas (30). In other studies, it has been reported that one of the main causes of DKA in previously diagnosed patients is inadequacies and deficiencies in accessing health services (31, 32). Our study determined that almost all of the previously diagnosed patients had their last routine control examinations performed long ago. The reason for this is limited access to health services and insufficient specialist doctors compared to the number of diagnosed patients in the region. We consider that the incidence of DKA may decrease slightly with the improvement of the quality of health care that should be provided on a routine basis.

The limitations of the study: (1) Single-Center Study: Conducting the study in a single center may limit the generalizability of the findings to other settings or populations. Different healthcare facilities, regions, or patient demographics could yield different results; (2) Sample Size: The study may be limited by a small sample size, which could reduce the generalizability of the findings. A larger sample size would provide more robust results and enhance the study's external validity; (3) Retrospective Design: The study's retrospective design may introduce inherent limitations, such as reliance on medical records and potential missing or incomplete data. It is crucial to acknowledge these limitations when interpreting the study's results and drawing conclusions, as they may influence the internal and external validity of the findings. Future research should aim to address these limitations to further advance knowledge in this area.

CONCLUSION

Prehospital care of DKA patients is especially important for referral patients living in remote healthcare settings. The use of telemedicine during the transport of patients diagnosed with DKA improves outcomes. Randomized controlled trials of the use of telemedicine in the prehospital care of DKA patients are needed.

We conducted a single-center study here, and despite the good results we obtained, we could not clearly determine the effect of telemedicine on complications and outcomes. Our results about prehospital care of

patients were similar to the previous study conducted in our country (17). The important thing here was to ensure that DKA patients with intensive care indications could be managed in the best way in a reference hospital where a limited number of specialist physicians work. We believe that teleconsultation prevents undesirable consequences that may occur both during transport and during intensive care follow-up, by ensuring that patient follow-up and treatment are adjusted correctly.

Although there is information in the literature about the usability of telemedicine in the follow-up and treatment of T1DM, information on the use of telemedicine in DKA is limited. What will be the impact of telemedicine on timely diagnosis of DKA in children and initiation of treatment, and whether telemedicine-based treatment of DKA provides better results (e.g. resolution of DKA, length of hospital stay and complications) compared to face-to-face treatment, effects of telemedicine on cost, issues such as adherence to treatment plans with telemedicine, how telemedicine affects the frequency and effectiveness of follow-up and monitoring in recovering patients, and the usability of telemedicine to educate and empower caregivers of children with diabetes to recognize early signs of diabetic ketoacidosis and take prompt action may be elucidated in future randomized controlled trials.

ETHICAL DECLARATIONS

Ethics Committee Approval: The study was carried out with the permission of Mersin University Clinical Researches Ethics Committee (Date: 15.12.2021, Decision No: 2021/755).

Informed Consent: Because the study was designed retrospectively, no written informed consent form was obtained from patients for the study.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

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